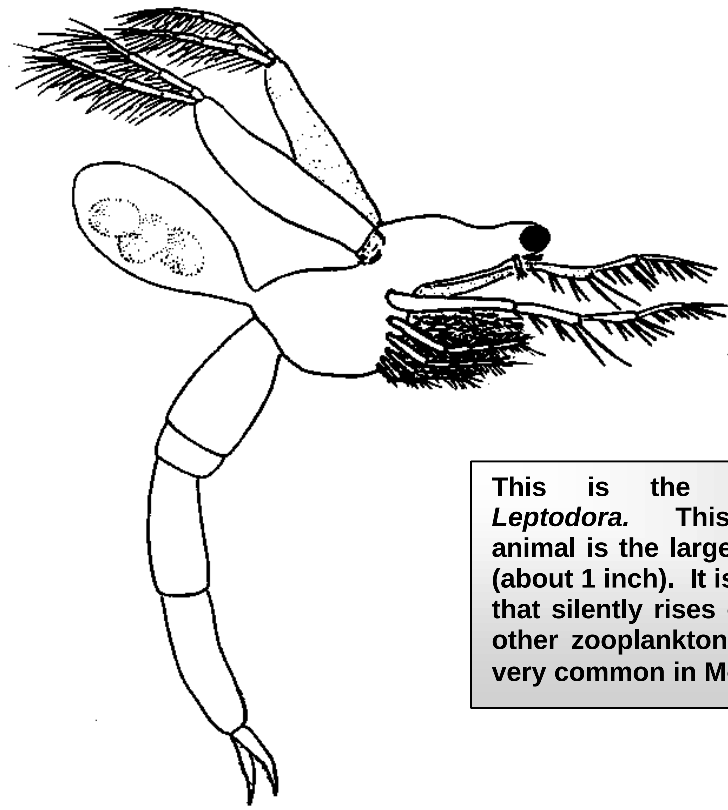
A Comparison of the Mid-Water Planktonic Invertebrate Communities of Eagle Creek, Geist, and Morse Reservoirs in Central Indiana Using Underwater Light Trapping



This is the zooplankter named *Leptodora.* This almost transparent animal is the largest of the cladocerans (about 1 inch). It is a voracious predator that silently rises each night to feed on other zooplankton. It was found to be very common in Morse Reservoir.

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October 31, 2000
IDEM 32/03/005/2000

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A Comparison of the Mid-Water Planktonic Invertebrate Communities of Eagle Creek, Geist, and Morse Reservoirs in Central Indiana Using Underwater Light Trapping

Introduction

Water quality affects the abundance, species composition, stability, productivity, and physiological condition of the invertebrate zooplanktonic community of any body of water. The term zooplankton refers to those invertebrate animals that live free-floating, free-swimming, or suspended in the vertical component of the open water. Zooplankton typically have short life cycles and respond quickly to environmental changes. Therefore, the standing crop and species composition of this community reflects the current and very recent quality of the water in which they live (Water Pollution Control Federation, 1985).

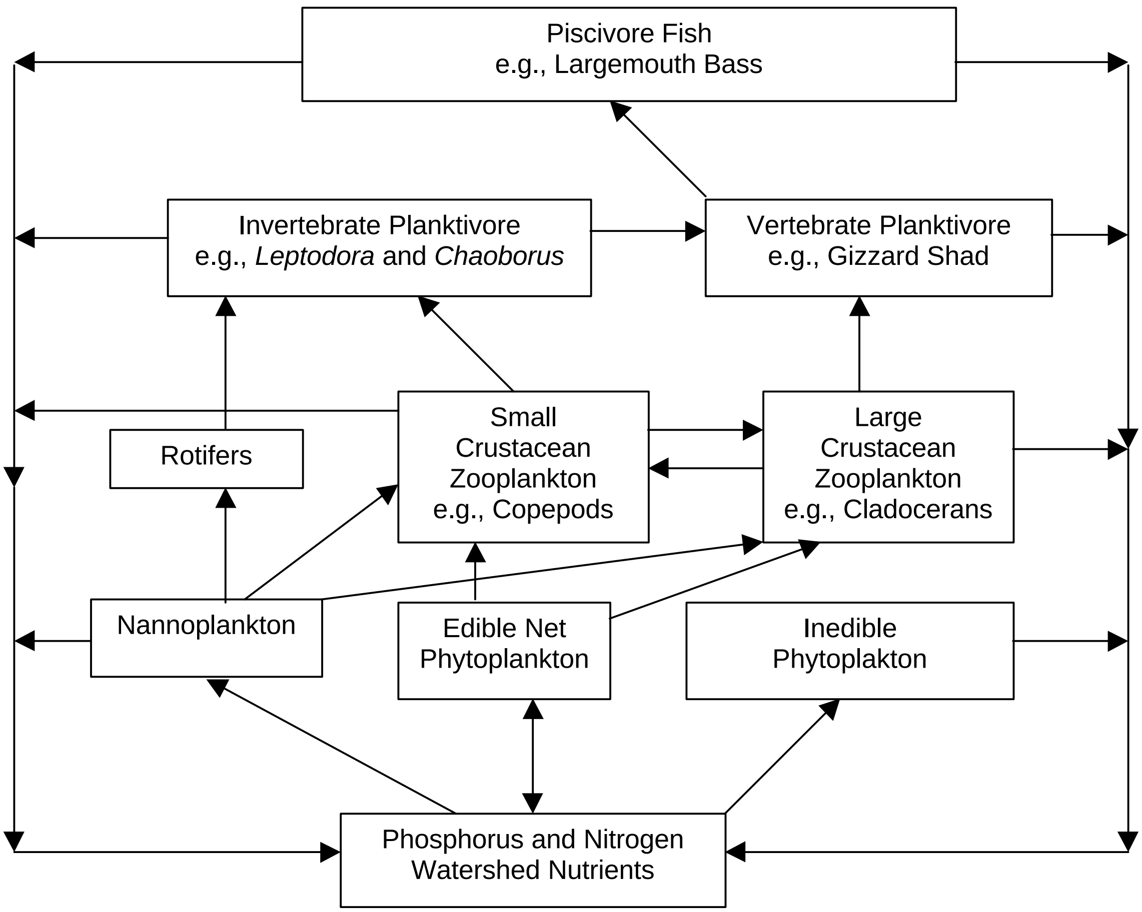
The water quality problem at Eagle Creek Reservoir began with an overabundance of inorganic nutrients, such as phosphorus and nitrogen (most Indiana waters typically are not nitrogen limited). These nutrients are passed through the food-chain starting with an increase in the overall abundance of algae. These changes in the food-chain both directly and indirectly affect the "water quality" of the reservoir (see Figure 1).

The dynamics of food-chains, in and of themselves, also influence water quality. Biomanipulation uses these system dynamics to manage water quality. For example physically large species of cladocerans are efficient in cleaning up lakes made turbid by blue-green algae (cyanobacteria). Thus, any "biomanipulation" that would increase the abundance of such cladocerans could help maintain a reservoir's water quality (Dodson and Frey 1991).

The addition of algaecide is a form of biomaniplation in an attempt to reduce the number of undesirable species of algae (e.g. *Pseudoanabaena spp*., *Oscillatoria chalybea*, *Lyngbya spp*.). These naturally occurring species can bloom to a point where they release intracellular metabolites in quantities which can cause taste and odor problems in water and fish tissue (such metabolites include the chemicals 2-methylisoborneol (MIB) and Geosmin). These particular taste and odor producing substances can also be produced by actinomycete fungi.

The purpose of this study was to determine and compare the relative abundance of the populations of light responsive zooplankton within three reservoirs, one of which (Eagle Creek) had an algaecide application during July 24-28, 2000. The impetus of this study was the fact that there had been a fish kill on Eagle Creek Reservoir, possibly in response to the algaecide application. The algaecide application proposal as submitted to the Indianapolis Water Company (IWC) by their contractor is presented in Appendix I.

Figure 1 Food Chain Model with Four Trophic Levels
(adapted from Dodson and Frey 1991)



The algaecide permit application was reviewed by the Indiana Department of Natural Resources (IDNR) and the Water Quality Standards Section, of the Indiana Department of Environmental Management (IDEM). Subsequent to the fish kill the Assessment Branch of IDEM became involved in a series of field investigations including extensive water chemistry testing of Eagle Creek Reservoir. This particular study was conducted at the request of the IDEMs' management to determine if the invertebrate populations of the system were affected.

The proposed study hypothesis was to evaluate the light trap response of the current living zooplankton community of Eagle Creek Reservoir relative to those living within the two nearby control reservoirs. This study utilized the known phototropic response of most zooplankton organisms which is the inherent characteristic that most zooplanktonic animals will actively swim toward a light source during the night-time hours--thus are collectable by an underwater light trap. No statistical difference in the phototropic response should be measurable if the algaecide had no affect on the zooplankton community of Eagle Creek Reservoir. If the measured response of the zooplankton community of Eagle Creek Reservoir was found to be significantly reduced or absent then a measurable affect on the existing food–chain can be inferred. A list of literature references of this sampling methodology is attached (Attachment 1).

Copepods and cladocerans have an important functional role in a lake ecosystem. The functional role of this particular group of species is that they provide an important link in the energy dynamics of the system and serve as a food base in the aquatic food-chain for vertebrate and invertebrate predators. Maintenance of the integrity of the links of the food-chain, from top-to-bottom (Figure 1) is critical to the overall health and ecology of the lake systems.

Copepod growth rates, as defined by the time needed for the population to double, normally can occur in 1-2 weeks. Populations can double in less than 2 days under optimal conditions of food density, mate density, water quality, and temperature. The relative abundance of calanoid versus cyclopoid copepods can vary with the functional structure of the ecosystem. It has been reported that as the productivity of the system increases, the abundance of cyclopoid copepods and cladocerans increases, while calanoid abundance either decreases or varies independently (Dodson and Frey 1991). It has been reported that calanoid abundance is the greatest when food quality is low or when food density is either extremely high or extremely low. Predation by invertebrate predators, such as the larval phantom midge *Chaoborus* and the cladoceran *Leptodora,* may significantly reduce their numbers thus explaining the inconsistent relationship between calanoid abundance and lake trophic status. To understand the complete dynamics of any one of these reservoir systems would require extensive study.

Eagle Creek, Geist, and Morse reservoirs are west, east and north of the city of Indianapolis, Indiana, respectively. All three reservoirs serve as a water storage system for the Indianapolis Water Company (IWC), as well as serving as recreational reservoirs for central Indiana (Figure 2).

Eagle Creek Reservoir drains 168 square miles of the Eastern Corn Belt Plains Ecoregion in the State, has a surface area of 1,350 acres, and retains 7,820 million gallons of water. It was built in 1959 or 1960 (personal communication IDNR, Division of Water). USGS published records for Eagle Creek Reservoir begin in 1970. Eagle Creek flows through the lake. There are many tributary inlets. The main ones include: Irishman Run, Cotton Creek, Sheets Creek, Hopewell Creek, McCurdy Creek, and Fishback Creek. Eagle Creek flows from the lake at the southern end, eventually emptying into the White River.

Geist Reservoir drains 215 square mile of the Eastern Corn Belt Plains Ecoregion in the State, has a surface area of 1,776 acres, and retains 6,901 million gallons of water. It was built in 1941 (personal communication IDNR, Division of Water). The Geist Reservoir USGS published records begin in 1961. Geist Reservoir was formed by an impoundment of Fall Creek. The tributaries are: Thor Run, Thorpe Creek, Mount Zion Branch, Bee Camp Creek, Bills Branch, North Fork, Middle Fork, and Dry Branch. Fall Creek flows from the reservoir at the southwestern end and empties into the White River, 17.6 miles downstream.

Morse Reservoir drains 214 square miles of the Eastern Corn Belt Plains Ecoregion in the State, has a surface area of 1,350 acres, and retains 6,900 million gallons of water. It was built in 1956 (personal communication IDNR, Division of Water). The Morse Reservoir USGS published records also begin in 1961. The reservoir is formed from Cicero Creek, which flows through the reservoir. The major tributary streams are: Little Cicero Creek, Bear Slide Creek, and Hinkle Creek. Cicero Creek flows from the reservoir at the southern tip and empties into the White River, approximately 4.8 miles downstream.

METHODS

Light trap samplers were placed in the reservoirs on August 9 and retrieved on August 10, 2000, utilizing a boat. Three underwater light trap samplers were placed on each of the three reservoirs. The light traps were anchored to the bottom and suspended from a float on the surface. Each site was at mid-reservoir in a lateral direction. The sites were located longitudinally the length of each reservoir (Figure 2). Sites were located using 1:24,000 USGS topographic maps. Latitude and longitude was determined using GPS (Table 1) and maps were prepared using Geographic Information Software (ArcView™) (Figures 8, 9, 10).

Each light trap was attached to the anchor line in a horizontal position and suspended 1.5 meters below the surface (Figure 3 and Figure 4). The collection period was such that each trap was suspended for an approximately equal period-of-time extending over a constant sunset to sunrise period. At the time of placement a 6-inch, 18-24 hour chemical light stick (white) [Glowstickfactory.com] was activated and placed in each trap. The time of setting and collection were recorded for each trap (Table 1).

Samples were retrieved into the boat. A 243-micron mesh screen was placed over the mouth of the sample jar and the water within the trap was decanted off to below one pint (<0.5 liter). Sixty milliliters of formalin were then added to the sample. Each preserved sample was provided with an internal and external label following the Biological Studies Section’s standard operating procedure. Sample identification numbers were also established using the location designations as depicted in all figures and tables in this report (E1, E2, E3; M1, M2, M3; G1, G2, G3).

All nine samples were returned to the laboratory for processing and taxonomic identifications. It was anticipated that these underwater light trap samplers would collect the free-living planktonic organisms that range in size from such zooplankton as opossum shrimp (Mysidacea), which are measured in inches, down to microscopic zooplankton. The microfauna includes many crustacea such as the small cladocerans (Order Branchiopoda) including the families Holopediidae, Sididae, Chydoridae, Daphniidae, Bosminidae, Macrothricidae, Moinidae, Leptodoridae, Cercopagidae, and Podonidae (Williamson 1991). It also includes the Copepods (Order Copepoda) including the two suborders Calanoida and Cyclopoida including the families Centropagidae, Diaptomidae, Pseudocalanidae, and Temoridae. It would also include the Class Ostracoda including the families Darwinulidae, Candonidae, Cyprididae, Cypridopsidae, Ilyocypridae, Notodromadidae, Cytheroidea, Entocytheridae, Limnocytheridae, Loxoconchidae, and

Neocytherideididae (Delorme 1991). Other free-swimming invertebrates which were expected included the large diverse group of arthropods known as water mites (Hydracarina; Parasitengona) (Smith and Cook 1991).

Organisms were identified to a standardized level and comparative counts were made using a 0.5-liter Folsom plankton splitter, as needed for sub-sampling (indicated in the results section). Upon returning to the laboratory, the formalin-fixed samples were drained through 243-micron screen netting and rinsed with 30% isopropyl alcohol. All samples were placed in 100mm petri-dishes and identifications and enumeration's were made under low power using a dissection microscope and analog bench-top counters. Data reduction and data management included reducing samples to abundance counts of the taxonomic identifications, which were recorded onto laboratory bench sheets.

All specimens were represerved in isopropyl alcohol and currated to the lowest taxonomic level possible and retained for future processing, museum reference, and bio-geographic information purposes for the Indiana Biological Survey.

The relative counts for each sample were analyzed using graphic and statistical tools to interpret the relative abundance, taxa richness, and diversity of the zooplankton communities. The counts were analyzed using Statistica™ software. The relative within-reservoir variability of the data set was examined using the three-replicate design of the study. Numerical analysis of the normalized and raw data sets was made using Euclidean distance similarity indices and cluster analysis. Cluster analysis utilized the Ward method for linking the individual similarity indices for both normalized and raw data sets. Once an integrated numerical analysis of the data was conducted, the site data were appropriately pooled and a relative abundance model proposed for the system.

Samples of the benthic macroinvertebrates living within the near-shore environment were sampled using a large square frame dip net with 0.5mm mesh. Samples were collected in water willow (*Justicia americana*) beds at the downstream dam end of each reservoir. Each sample was collected by wading and collections were made by sweeping the substrate in association with the emergent vegetation, for a period of one minute. The samples were rinsed into a large white nylon pan and all macroinvertebrates were counted and recorded on a Rapid Bioassessment (III) field sheet with the relative abundance recorded as rare (<3), common (3-9), abundant (>10) or dominant (>50). All specimens collected were returned to the water. These collection sites are located on Figures 8, 9, and 10.

RESULTS AND DISCUSSION

Figure 1 presents a model for the food-chain of a typical lake system. The attempt to biomanipulate this food-chain by the application of an algaecide is complicated in that it can have significant, unexpected, or unmeasured effects on the lake ecosystem. One such effect could be the death of a high-end predator (such as the observed hybrid striped bass fish kill) subsequent to the application of the algaecide. Whether the fish die-off was due to oxygen reduction, direct or indirect toxic effects of the algaecide, natural population adjustments caused by parasitism or disease are speculative. This study was not an attempt to determine the cause of the fish kill but an attempt to determine if an important part of the food-chain had also been eliminated or statistically altered. This was accomplished by a method that allowed a statistical comparison of zooplankton that were healthy enough and had the ability to respond to the light stimuli of underwater light traps located within the 3 local reservoirs.

Almost 30,000 zooplankton were collected, identified, and enumerated in this study. Figure 2 presents the relative location of each of the three reservoirs and Figures 8, 9, and 10 present the exact sampling locations. Table 1 shows the latitude and longitude of each site, as well as the period of collection, water depth, and water visibility at the time of sample collection.

It should be noted that the average water depth of the mid-reservoir sample sites was 27, 16, and 29 feet for Eagle, Geist and Morse Reservoirs, respectively. The shallow end samples E1, G1, and M1 were 2, 3 and 4 feet. This means that the light traps at the shallow end sites were in close proximity to the reservoirs' bottoms and as a result collected bottom-associated taxa. This is unlike the E2, E3, G2, G3, and the M2, M3 sites which collected more typical mid-water planktonic organisms. Therefore, the mid- and deep-end samples were accepted as those samples that best represent the compositional and structural characteristics of the mid-water zooplankton community. The water visibility, as expected, was found to be about two feet at the mid- and deep-end sites, while the headwater sites on each reservoir were closer to 1 foot.

Table 2 presents the taxonomic results of this study. All counts are actual counts with only the Morse Reservoir samples requiring use of the Folsom plankton splitter. Morse Reservoir taxonomic counts were then back calculated from the multiplication factor of the number of 50% splits of the original sample.

The most zooplankton was collected from Morse Reservoir, with 18,622 animals (65.8% of all individuals across all reservoirs). Geist Reservoir was second in abundance with 24.6% of the individuals, while Eagle Creek Reservoir had only 9.6% of the total abundance. These percentages are somewhat misleading in that the upstream samples (the 3 sites at the shallow end of each reservoir), when combined, represented 19,387 of the 28,292 organisms collected; or about 70% of all zooplankton collected in the 9 traps. Therefore, it is appropriate to assume that the upstream sites (E1, G1, and M1) represent different habitats when compared to the mid-reservoir and deep-end reservoir sites. As stated earlier, this is probably due to the physical proximity of the sampling devices to the distinctly unique benthic community (animals associated with the bottom substrate) of the reservoir. As such these samples need to be excluded from the final model in the characterization of the mid-water plankton community.

If the upstream sites (E1, G1, and M1) are eliminated from the analysis, and the relative abundance of the two remaining samples are pooled, the results are presented in Figure 5. As can be seen, the absolute abundance of mid-water zooplankton is statistically indistinguishable between Eagle Creek Reservoir and Geist Reservoir. On the other hand, approximately seven times as many zooplankton were collected in Morse Reservoir. The observation concerning absolute zoolankton counts is interesting, since

Morse Reservoir apparently underwent a Cutrine Plus™ treatment in 1989 (Appendix I) and yet had a much higher zooplankton density than either of the two other reservoirs. There is no record that Geist Reservoir has had such an algaecide treatment, and yet Eagle Creek and Geist Reservoir have a significantly lower density of mid-water zooplankton than Morse Reservoir exhibited.

A sophisticated multivariate numerical classification analysis of data in Table 2 supports the exclusion of the upstream sites from the analytical results because the upstream sites are taxonomically and numerically different from the mid-reservoir and deep-end reservoir samples. Figure 6 presents these analyses. Figure 6A represents the count and taxonomic similarity matrix expressed as a Ward amalgamation dendogram. This analysis normalized the data and used a similarity index known as an Euclidean distance measurement. This index of similarity maintains the numerical pattern with equal weight on the normalized counts. For example, if you had two theoretical samples, each with three species and a structure of 50%, 20%, 30%; they would be 100% similar and would be connected at the 0 level of the [(Dlink/Dmax)*100] dissimilarity scale. Any change in the percentages or additions or subtractions of taxa would decrease the calculated similarity index between the sites. While this is a scale of dissimilarity, it is sometime more convenient to think in terms of degree of numerical similarity. This conceptual method is further explained in Ludwig and Reynolds (1988).

Figure 6A indicates that samples G3 and E2 are most similar. It also shows a subgroup similarity structure indicating that E3 and G2 are the next most similar sites, but they in turn are most similar to E1 and are next-most similar to the (G3, E2) subgroup. All five of these samples are less than 10% different (90% similar) from each other in their taxonomic and numeric sub-structure characteristics. Figure 6A also indicates that the four next-most similar are M3, M2, G1 and then finally M1, which is indicated to be similar at the 100% level when compared to all other samples.

To clarify the "relative" similarity of the samples from the results in Figure 6A, additional numerical classification analysis was performed. Figure 6B indicates the relative similarity elucidated in Figure 6A. This represents the data on a relative scale showing that the relative-difference between the (E2, G3) subgroup to the (E1, E3, G2) subgroup is significant. To put this in perspective, on a scalar relationship to the next most similar sample, Figure 6C was prepared (which includes the M3 sample) to show the degree of sample similarity of the raw counts.

Table 3 is the summary model of the pooled data sets between all groups of samples on a more appropriate relative abundance scale. This table brings back the concept of modeling the "relative abundance" after examining both the raw data and the pooled relative abundance by numerical analysis. Table 3 represents the collective model of what these "grouped sites" have to say about the relative abundance of the taxa as represented in Table 3. Figure 7 then reflects the similarity of this data matrix of relative abundance (0.5% was used to represent <1% values). As such, it represents the data in its most refined scaler relationship of similarity based on the exploratory data analysis of these steps.

In Figure 7 we see the most similar sites using the pooled taxonomic composition and pooled relative abundance (Table 3). The results indicate that subgroup (E2, 3;G2, 3) pools with site M3 with about a 12% difference between these two subgroups. The next two samples most similar to each other are M1 to M2 at about an 18% difference. The next closest affinity is the E1 sample to the (E2, 3;G2, 3; M3) subgroup with about 32% difference. This group then amalgams with the (M1, M2) subgroup at about the 79% level. Figure 7 shows that in fact the most dissimilar sample is the G1 site. This is a summary of the results of the final numerical classification analysis with most similar sites examined using the pooled taxonomic composition and pooled relative abundance data. These sites were then rearranged in position to match this cluster analysis in Table 3.

SUMMARY AND CONCLUSIONS

Numerical classification analysis is a very useful and objective means by which exploratory data analysis can be conducted to find and measure the amount of numerical similarity between different data sets. Numerical classification analysis allows the simultaneous examination of numbers and kinds of animals in a sample and objectively represents these multivariate differences on a comparative numerical scale. In using this methodology, it is always important to examine both the raw data as well as the percentage expressions of these data. Each kind of data presentation contains information about the samples and thus the system or population they are representing. Once the relationships and patterns have been examined, the samples can be rearranged in such a way that these numerical patterns can be easily observed and then statements of why this may be can be further explored.

This study used underwater light traps to collect and measure the relative abundance of mid-water zooplankton community as it responded to light. It was possible to show that the mid-water sample sites collected a comparable cross section of the zooplankton that could be used to make statistical and relational comparisons to the other sampling results. It was determined that the mid-water sites of Eagle Creek Reservoir and Geist Reservoir (E2, E3, G2, and G3) were statistically the same and taxonomically and structurally comparable to each other on a multivariate scale. It can therefore be concluded that the algaecide treatment of Eagle Creek reservoir did not affect the midwater zooplankton community as measured within this study. It was possible to graphically present the relative multivariate relationship of these 4 combined mid-water sites to the other 5 sites sampled (Figure 7). The four mid-water Eagle Creek and Geist mid-water sites, on a multivariate scale, were most similar to the M3 site sample (12% difference) and these five sites were next most similar to the E1 site sample (32% difference). The next most similar samples were the two samples located at M1 and M2 that were only 18% different from each other. The (M1, M2) subgroup samples were together comparable to the 32% group at the 79% difference level. The sample collected at G1 was determined to be 100% different from all other samples. The relative abundance characteristics of the 11 taxa identified in this study can be examined in Table 3 and are presented as the numerical model of this particular data set.

While these data provided a useful tool to compare each sample and each reservoir it would be of much greater sensitivity and have greater ecological assessment value if the time was taken to identify samples to a lower taxonomic level. This study would indicate that this sampling method and device could provide a useful tool in monitoring lake faunal communities.

The sweep net collections of near-shore macroinvertebrate samples were not extensive enough to provide information to be used in this assessment. The sampling effort and range of habitat sampling would need to be significantly increased to provide adequate assessment data.

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Figure 2: Location of Eagle Creek Reservoir, Morse Reservoir, and Geist Reservoir

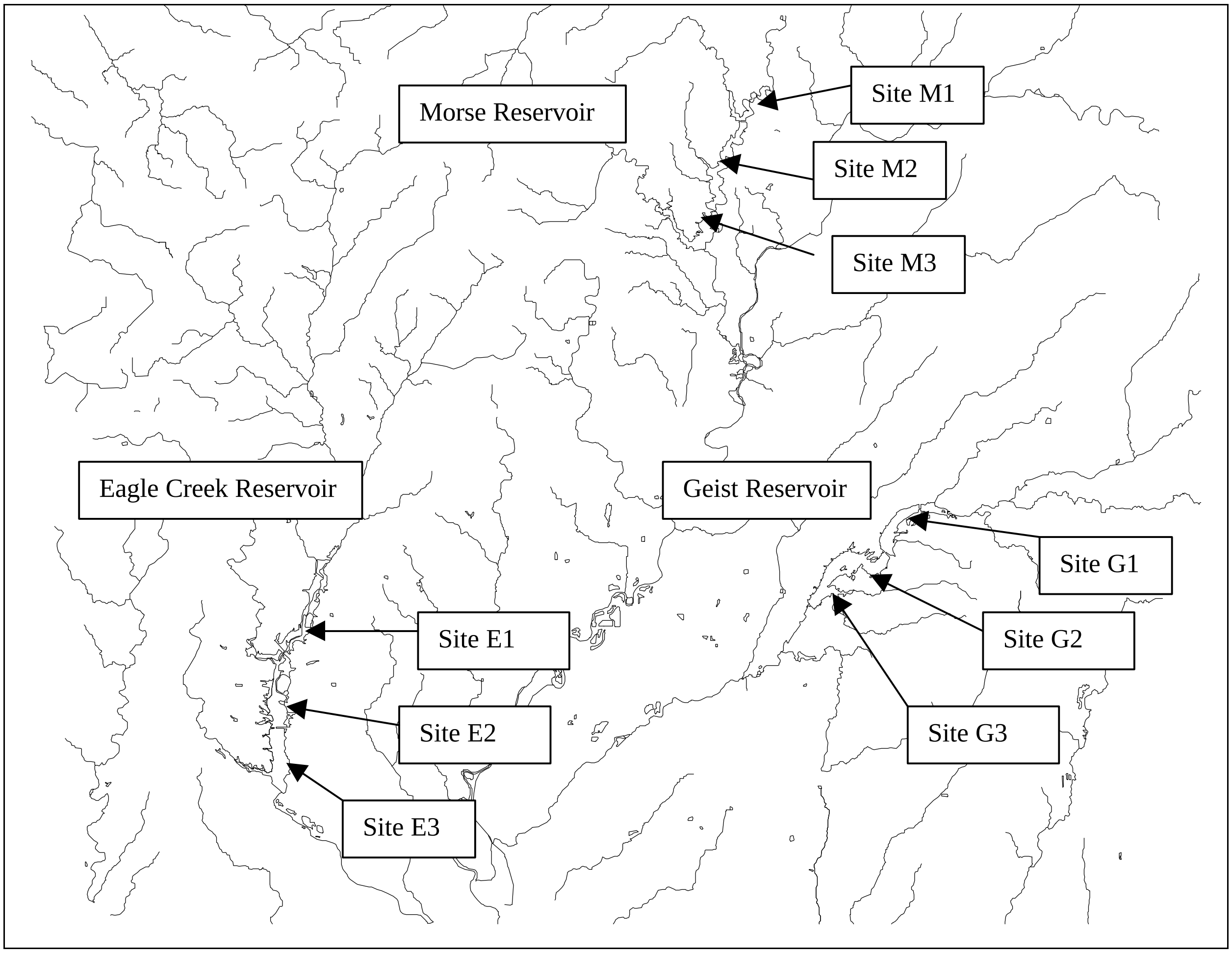


Figure 3: Underwater Light Trap

Figure 4 Placement of Underwater Invertebrate Activity Light Trap

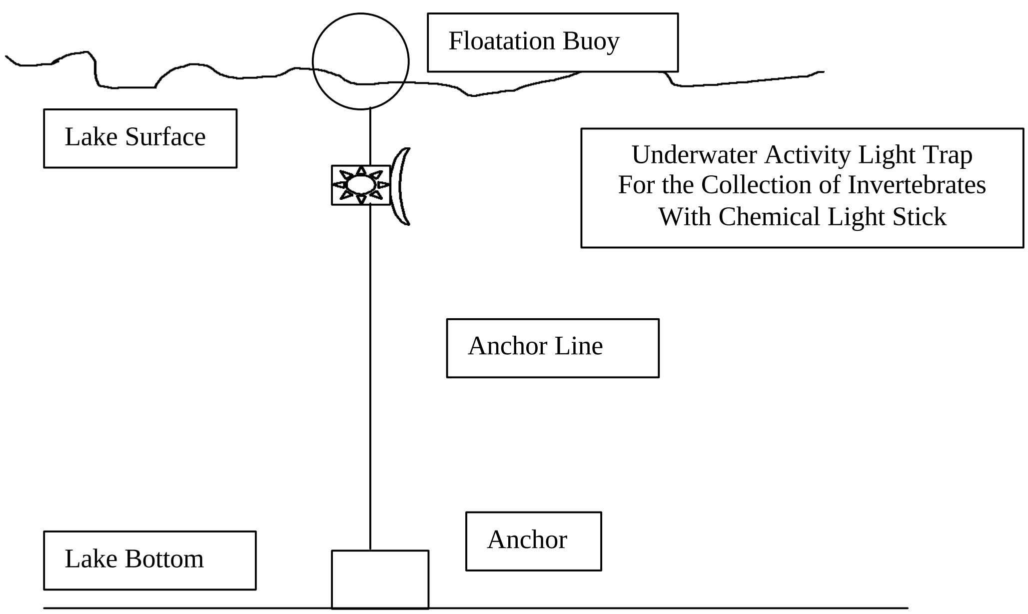


Figure 5 Average Number of Zooplankton Collected per Light Trap

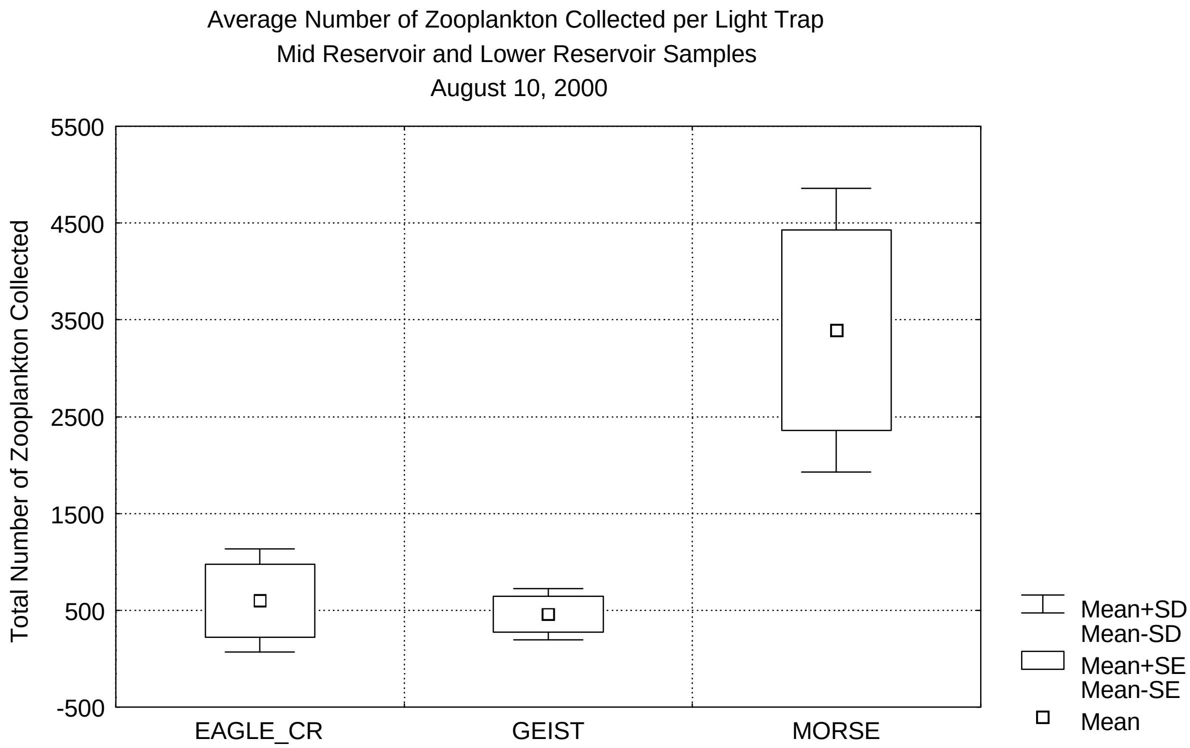


Table 1 Underwater Light Trap Site and Collection Period Information

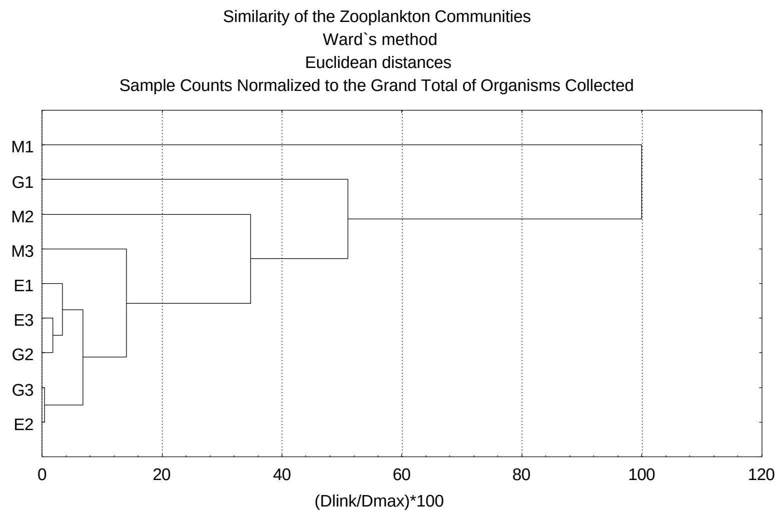
Site ID	AIMS Site ID	AIMS Event ID	Sample Number	Latitude	Longitude	Collection Period Aug 9- 10 2000 (hours)	Site Depth Meter (feet)	Secci-Disk Visibility (feet)
E1	WWU120-0036	AA01635	LT000810209	39 52 34.77	86 18 20.04	1925-1745 (22.3)	0.7 (2.3)	1.0
E2	WWU120-0035	AA01634	LT000810208	39 51 23.15	86 18 18.23	1855-1718 (22.3)	4.6 (15.2)	2.4
E3	WWU125-0033	AA01631	LT000810207	39 49 41.53	86 18 41.74	1825-1632 (22.1)	12.0 (39.6)	2.4
G1	WWU100-0012	AA01625	LT000810203	39 57 4.75	85 54 53.44	1510-1112 (20.0)	0.8 (2.6)	1.1
G2	WWU100-0011	AA01625	LT000810203	39 56 4.83	85 56 22.04	1450-1049 (20.0)	2.9 (9.6)	1.5
G3	WWU100-0009	AA01621	LT000810201	39 54 39.12	85 58 50.28	1425-10000 (19.6)	6.7 (22.1)	2.0
M1	WWU080-0009	AA01630	LT000810204	40 4 21.25	86 3 4.69	1700-1358 (21.0)`	3.5 (11.6)	1.4
M2	WWU080-0008	AA01629	LT000810205	40 4 32.53	86 2 56.24	1645-1417 (21.5)	6.7 (22.1)	2.5
M3	WWU080-0006	AA01627	LT000810206	40 5 33.91	86 2 24.7	1625-1440 (22.3)	10.7 (35.3)	2.3

Table 2: Abundance of Zooplankton Collected at Light in Three Central Indiana Reservoirs

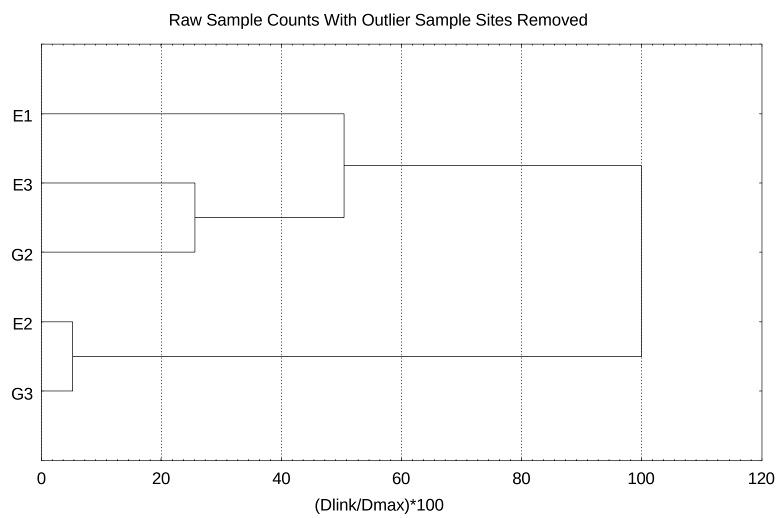
	Eagle Creek Reservoir				Geist Reservoir				Morse Reservoir				
TAXON	E1	E2	E3	E-TOTAL (% Total)	G1	G2	G3	G-TOTAL (% Total)	M1	M2	M3	M-TOTAL (% Total)	GRAND TOTAL
Insecta Odonata Zygoptera				0 (0)	1			1 (<0.1)				0 (0)	1 (<0.1)
Ephemeroptera Baetidae				0 (0)	7			7 (0.1)				0 (0)	7 (<0.1)
Caenidae				0 (0)	5			5 (0.1)				0 (0)	5 (<0.1)
Hexagenidae				0 (0)	3			3 (<0.1)				0 (0)	3 (<0.1)
Hemiptera Corixidae				0 (0)	1			1 (<0.1)				0 (0)	1 (<0.1)
Diptera Ceratopogonidae				0 (0)	1			1 (<0.1)				0 (0)	1 (,0.1)
Chironomidae Larvae	7			7 (0.3)	50	2		52 (0.7)	7		4	11 (0.1)	70 (0.2)
Pupae	14	9	1	24 (0.9)	29	2		31 (0.4)	148			148 (0.8)	203 (0.7)
Chaoboridae	88	12	11	111 (4.1)	23			23 (0.3)	1	2	2	5 (0)	139 (0.5)
Crustacea Branchiopoda Copopoda Calanoida	713	52	436	1201 (44.1)	1030	303	85	1418 (20.4)	9168	3382	750	13300 (71.4)	15919 (56.3)
Cyclopoda	497	149	529	1175 (43.1)	336	332	182	850 (12.2)	608	1026	1566	3200 (17.2)	5225 (18.5)
Branchiopoda Leptodoridae				0 (0)			2	2 (<0.1)	1642	16	32	1690 (9.1)	1692 (6.0)
Other Cladocera	28	1		29 (1.1)	81	8	4	93 (1.3)	264	2		266 (1.4)	388 (1.4)
Ostracoda	176	1		177 (6.5)	4443			4443 (64.0)			2	2 (<0.1)	4622 (16.3)
Arthropoda Acari Hydracarina	1			1 (<0.1)	15			15 (0.2)				0 (0)	16 (0.1)
SAMPLE TOTAL COUNT	1524	224	977		6025	647	273		11838	4428	2356		
Total Number of Organisms and Percent of Grand Total Collected in Underwater Light Traps on August 10, 2000				2725 9.6 %				6945 24.6 %				18622 65.8 %	28292 (100 %)
Total Number of Taxa				8				15				8	15

Figure 6 Classification Analysis of Zooplakton Counts Using Numerical Analysis of the Taxonomic Count Substructure

A



B



C

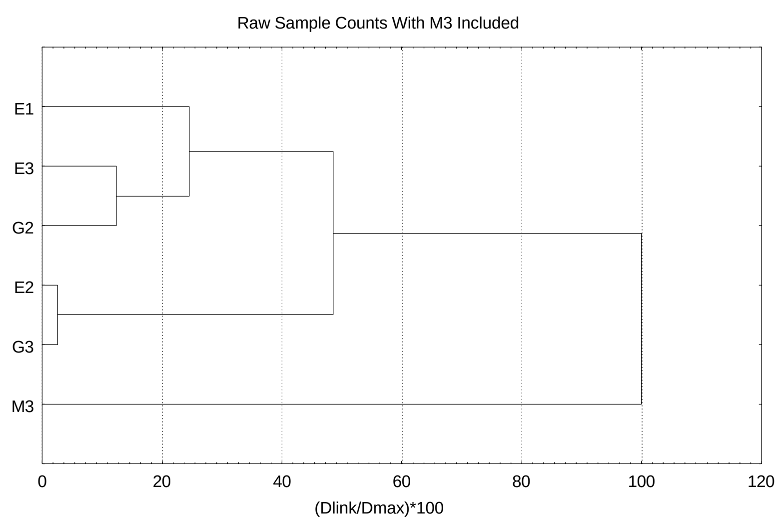


Table 3 Relative Abundance Model of Pooled Samples Based on Numerical Classification Analysis

Taxon	E2,3; G2,3 (% Sample)	M3 (%)	E1 (%)	M1 (%)	M2 (%)	G1 (%)
Odonata	0	0	0	0	0	<1
Ephemeroptera	0	0	0	0	0	<1
Hemiptera	0	0	0	0	0	<1
Other Diptera	0	0	0	0	0	<1
Chironomidae	1	<1	1	1	0	1
Chaboridae	1	<1	6	<1	<1	<1
Calanoida	41	32	47	77	76	17
Cyclopoida	56	67	33	5	23	6
Leptodoridae	<1	1	0	14	1	0
Other Cladocera	1	0	2	2	<1	1
Ostracoda	<1	<1	12	0	0	74

Figure 7 Cluster Analysis of Final Groups Relative Abundance

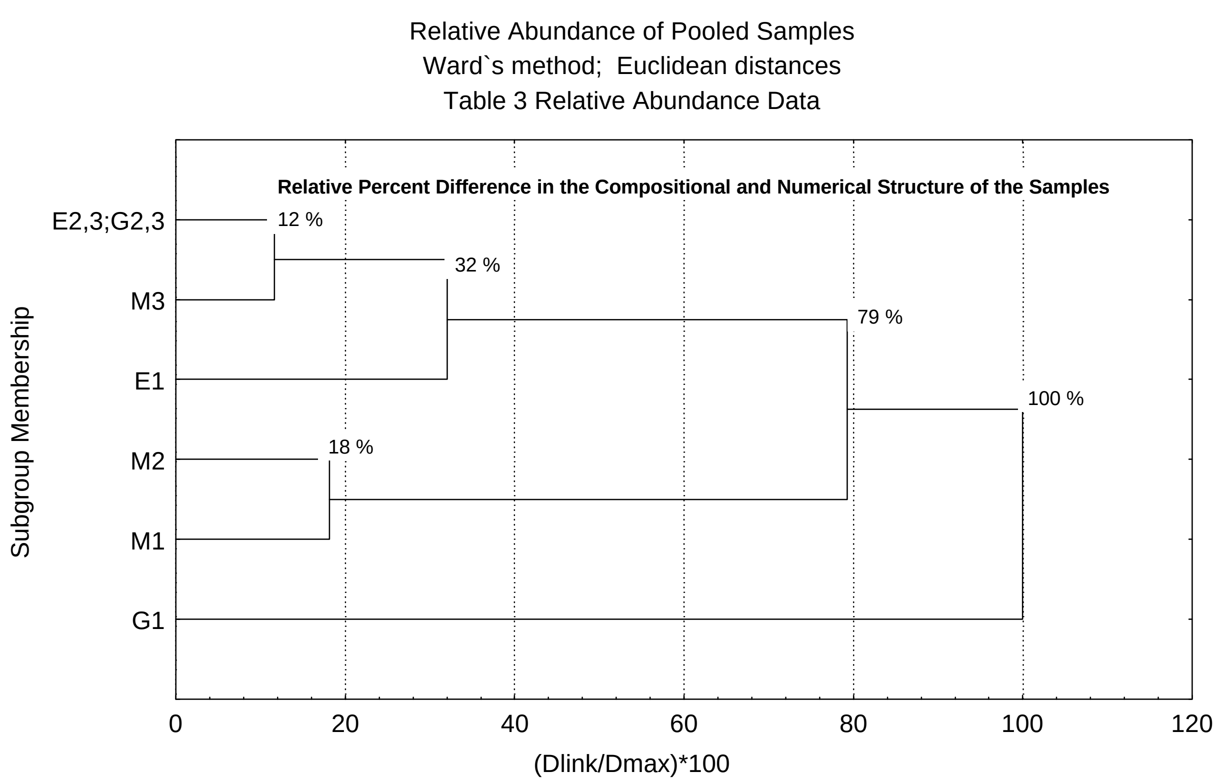


Figure 8

Eagle Creek Reservoir Plankton 08/10/00

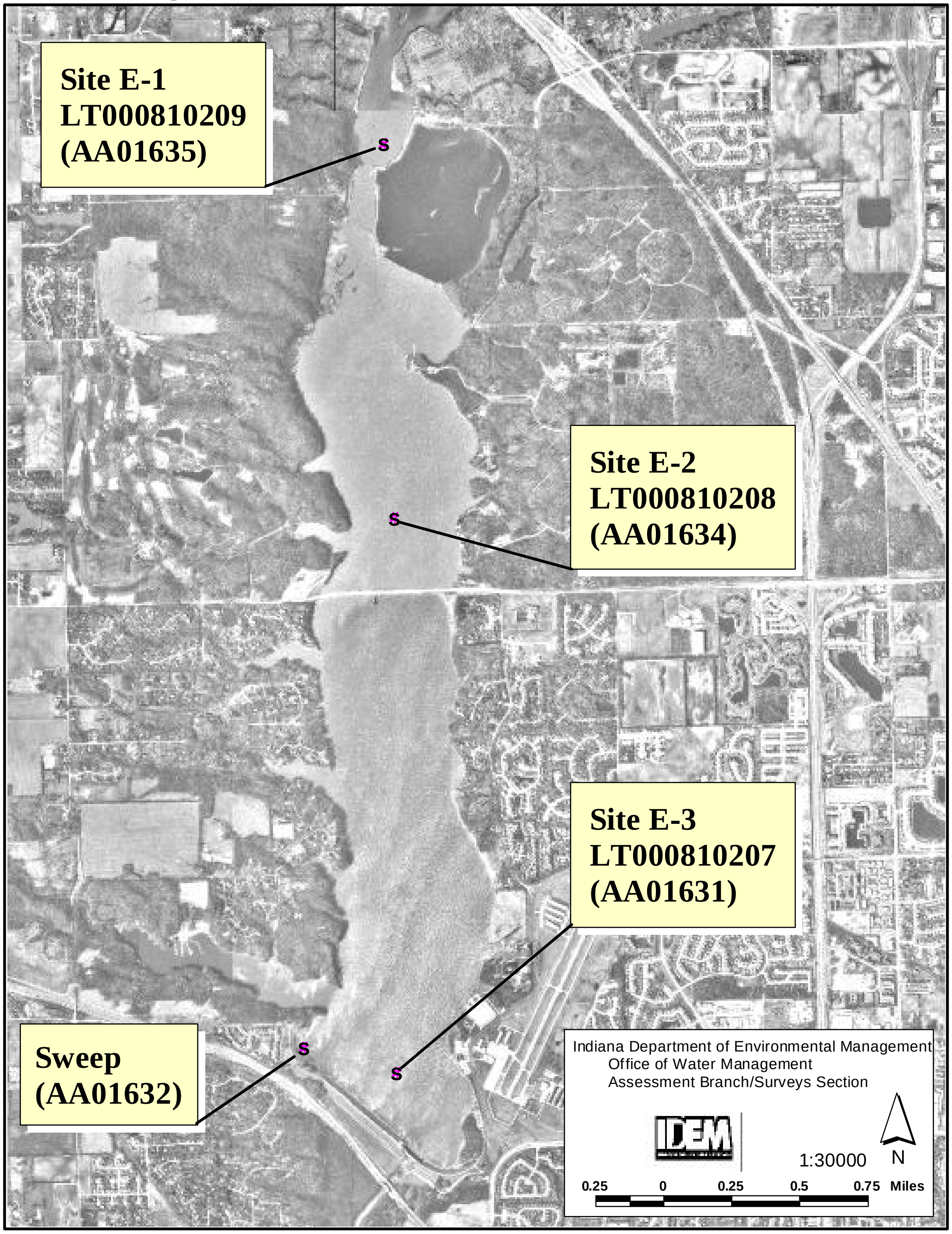


Figure 9

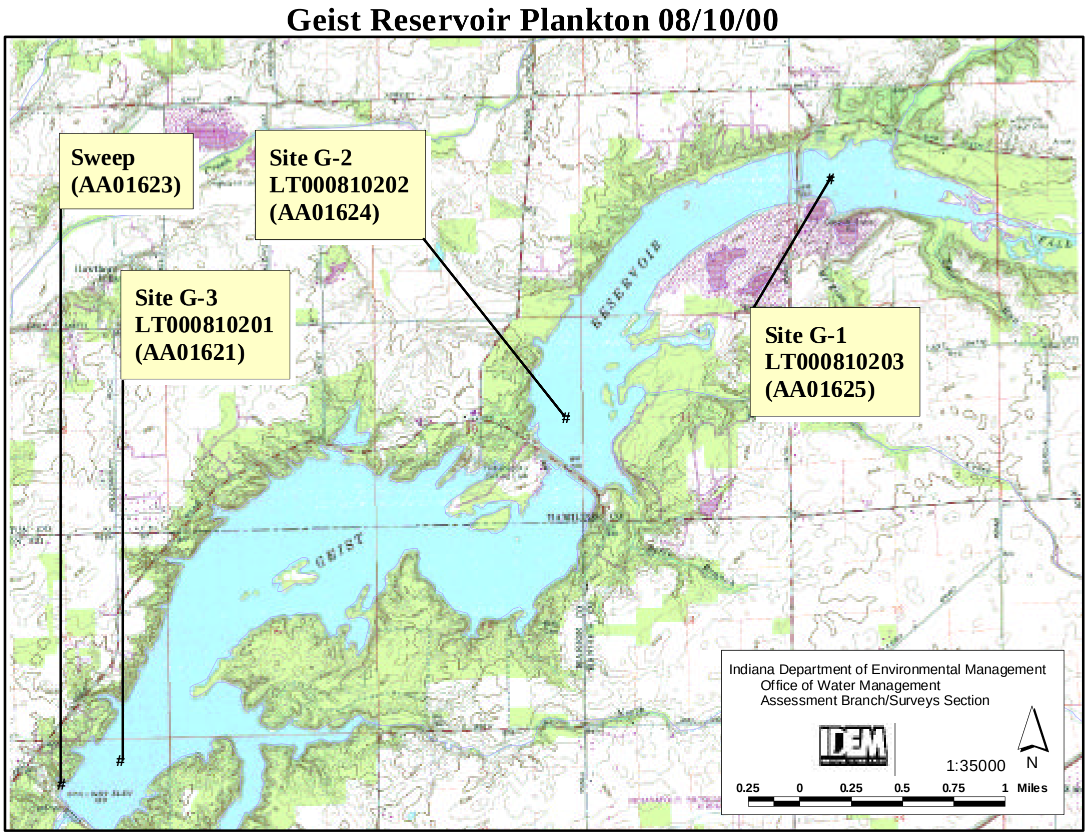
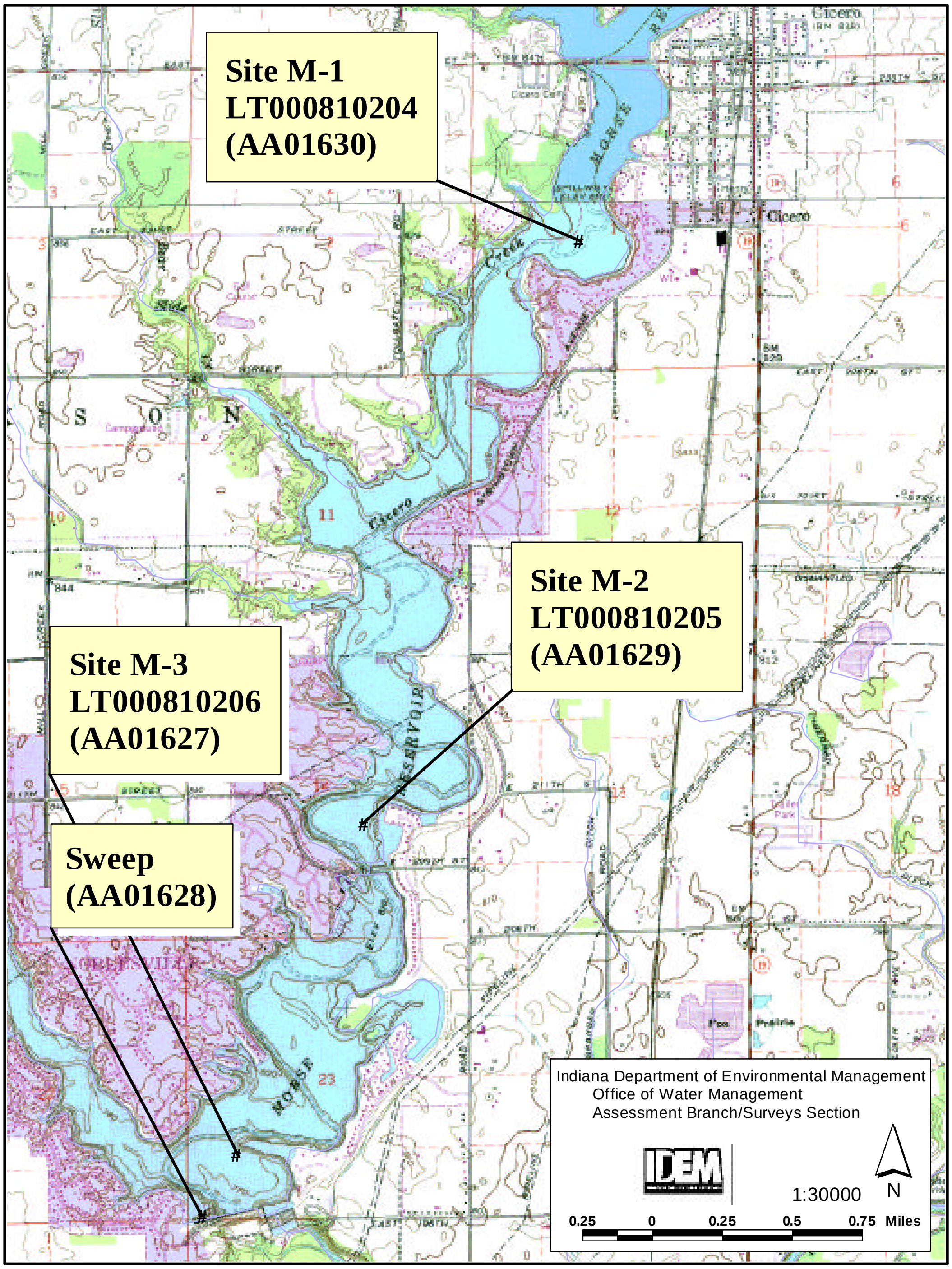

Geist Reservoir Plankton 08/10/00
Sweep
(AA01623)
Site G-2
LT000810202
(AA01624)
Site G-3
LT000810201
(AA01621)
Site G-1
LT000810203
(AA01625)
RESERVOIR
GEIST
Indiana Department of Environmental Management
Office of Water Management
Assessment Branch/Surveys Section
1:35000
N
0.25 0 0.25 0.5 0.75 1 Miles

Figure 10

Morse Reservoir Plankton 08/10/00



Attachment 1

The Use of Underwater Traps for the Collection of Aquatic Macroinvertebrates
A Literature Search
By Steven Newhouse

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APPENDIX I

The Cutrine Plus Algaecide Application Proposal as Submitted by a Contractor to the Indianapolis Water Company on 6/19/2000 for Eagle Creek Reservoir (Introduction and Treatment Protocol)

Chemical Treatment of Eagle Creek Reservoir

... is pleased to provide this proposal for the treatment of Eagle Creek Reservoir for the Indianapolis Water Company (IWC) to reduce nuisance population levels of *Pseudoanabaena sp*. Based on a dissolved oxygen profile on June 16 by IWC personnel and plankton samples collected at two locations in the reservoir on June 16 by IWC personnel, it has been determined that the *Pseudoanabaena* is distributed throughout the lake to the depth of at least 15 feet. Cell counts for *Pseudoanabaena* drop off very significantly at a depth of 18 feet. Cutrine Plus™ has been selected as the algaecide of choice to be used to achieve the desired control of *Pseudoanabaena* in the lake, based upon previous experience with this product on Morse Reservoir in 1989 and support from the manufacturer. Cutrine Plus™ was chosen to maximize treatment effectiveness and reduce fragmentation and regrowth of *Pseudoanabaena* filaments. By reducing the *Pseudoanabaena* population and its regrowth, we expect to see a reduction in MIB and Geosmin production.

Treatment Protocol

Depth contour maps of Eagle Creek Reservoir were measured using a compensating polar planimeter to determine total surface and total acre feet of water less than 16 feet in depth in the lake. The total surface area to be treated was determined to 1228 acres. The total volume of water in the top 16 feet of the lake was calculated to be 14,883 acre feet. Cutrine Plus™ will be applied at a rate in accordance with EPA Registered label instructions to achieve a calculated copper concentration of 0.2 mg/L in the treated water. A total of 8930 gallons of Cutrine Plus™ will be required to achieve this result. The lake was divided in nine treatment zones starting in the northern end of the lake with Zone 1 and proceeding south to Zone 9 at the dam (see enclosed map). The volume of water to be treated and the appropriate amount of Cutrine Plus™ has been determined for each zone. Surface spray and injection application techniques will be used. Application will be facilitated by airboats, john boats and nurse boats. One application crew will begin application on day one in Zone 1 and work through Zone 4. A second application crew will begin application on day one in Zone 5 and work through Zone 9. It is expected to take three days to complete the application. This could vary due to weather and other factors beyond our control. By applying the Cutrine Plus™ in this manner, the lowest possible amount *Pseudoanabaena* should be killed in the area of the water intake structure (located in Zone 5) at any one time. It is understood that IEC will accept delivery of the Cutrine Plus™, distribute the material to predetermined locations around the lake, and dispose of empty containers.